

Study Group 7

ELECTRONIC FUNDAMENTALS



Service Practices 13:

HOW TO TEST RESISTORS

Service Practices 14:

HOW TO TEST INDUCTORS



RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

New York,

N. Y.

ELECTRONIC FUNDAMENTALS

SERVICE PRACTICES 13

HOW TO TEST RESISTORS

- 13-1. Fixed Resistors**
- 13-2. Slider-Type Adjustable Wirewound Resistors**
- 13-3. Variable Resistors**
- 13-4. Taper**
- 13-5. Replacing Potentiometers and Rheostats**



RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.

Service Practices 13

INTRODUCTION

In earlier lessons, you learned about the materials that are used to produce resistance effects and how to use an ohmmeter to measure the amount of resistance. All radio and electronic equipment contains resistors that have been purposely placed in the circuit to control the flow of current. Most of these resistors are *fixed* and cannot have their resistance values changed. Some can be *varied*, or adjusted, to obtain the desired amount of resistance. Fixed resistors are usually made of carbon composition material, a metallic surface film, or resistance wire. Variable resistors are made either of materials that contain amounts of carbon or graphite, or of wound resistance wire. Variable-resistor units are called potentiometers (pots) or rheostats, depending upon how they are constructed or how they are used.

When resistors, potentiometers, and rheostats become defective, they cause radio and television receivers to stop operating entirely, become noisy, or operate improperly in one way or another. In this lesson, you will learn how to use the ohmmeter section of your multimeter to test, select, and replace both fixed and variable resistors.

13-1. FIXED RESISTORS

Insulated Composition Resistors. The most common type of fixed resistor used in radio and television receivers is made of a carbon

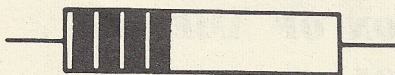


Fig. 13-1

composition in the form of a solid inserted in an insulated pressed or molded rod as shown in Fig. 13-1.

Electrical connection to this type of resistor is made to the two tinned copper leads extending from the ends of the resistor.

Some of the common faults found with carbon or metallic film resistors are:

1. Resistance value too much above normal
2. Resistance value too much below normal
3. Open resistor
4. Noisy resistor (A noisy resistor causes a grinding, crashing, crackling, or hissing type of noise in the loud speaker.)
5. Abnormal change in resistance value when resistor heats up (An ohmmeter can be used to locate the first three faults and *sometimes* the fourth, but not the fifth.)

Testing the Resistor With an Ohmmeter. Fig. 13-2 shows part of a radio circuit. It contains resistor R_1 , which we will consider to be defective. Let's consider how to test this resistor with an ohmmeter to find out what is wrong with it.

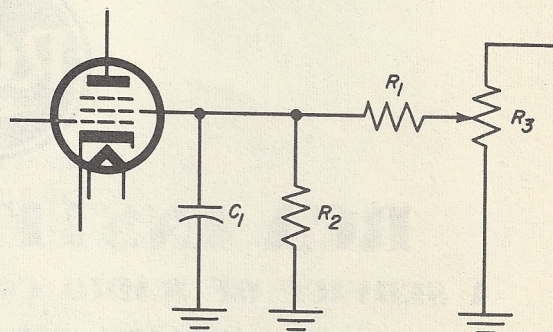


Fig. 13-2

Caution: Before using an ohmmeter to test any portion of a radio receiver, always follow these rules:

1. Turn the on-off switch of the radio receiver to off.
2. Remove the power-line plug from the wall socket to avoid personal injury and damage to meter and parts.
3. If the radio receiver is a portable-type set, disconnect the batteries to avoid damage to ohmmeter and tubes.

4. When testing a resistor in a radio or television receiver, always disconnect one lead of the resistor from any other part or parts to which it is connected in order to avoid wrong readings, unless you are sure that these other parts do not form circuits that are in parallel with the resistor being tested. Resistor R_1 in Fig. 13-2 should be disconnected from the circuit to avoid incorrect ohmmeter readings. If the resistor is not disconnected and the two ohmmeter leads are placed across R_1 , the ohmmeter will also read the circuit consisting of resistors R_2 and R_3 in parallel with R_1 . This means that, due to the shunting effect of resistors R_2 and R_3 , you may think that R_1 is normal even if R_1 is open or has a very high incorrect value of resistance.

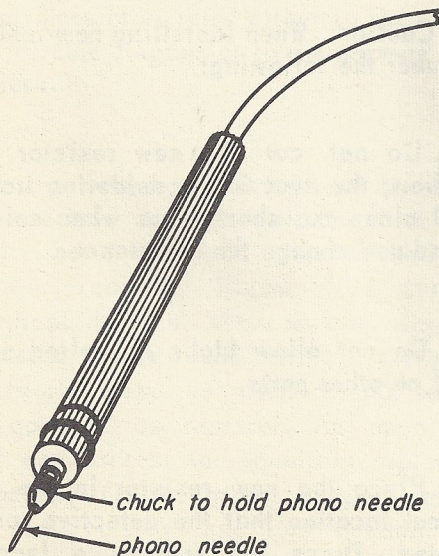


Fig. 13-3

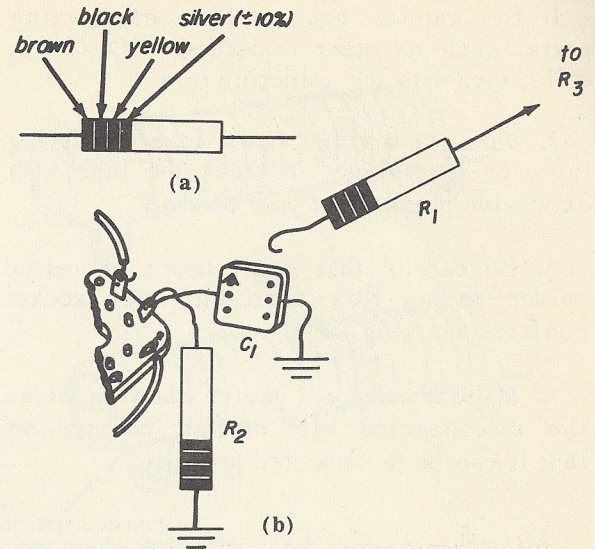


Fig. 13-4

When the ohmmeter is used to test a resistor, the test prods should be pressed firmly against the resistor leads. Figure 13-3 shows a special type of test prod that has a chuck to hold a phono needle. Because of the sharp point of the needle, such a prod makes a good positive contact. (In addition, it may be used to pierce through the insulation of rubber, plastic, or other covered leads when necessary for testing.) The metal tips of the prods should not touch the terminals or wires of other parts that do not connect to the resistor.

The resistor, color-coded as shown in Fig. 13-4a, is supposed to be 100,000 ohms and have a tolerance of $\pm 10\%$. As you learned in an earlier lesson, a tolerance of $\pm 10\%$ means that the resistor can measure between 110,000 and 90,000 ohms, as read on an ohmmeter. This resistance range is acceptable for use in this circuit in the radio receiver.

Now that you know what precautions to take before testing a resistor and what value the resistor is supposed to have, let's go through the procedure for testing resistor R_1 to see if its value is actually what the color code says it is. First, one end of R_1 should be unsoldered and disconnected from the circuit, as shown in Fig. 13-4b, in order to free it from the shunting effect of R_2 and R_3 . Remember the following rules for disconnecting resistors (or other parts) in a radio receiver:

1. Be careful not to burn neighboring parts, such as other resistors, capacitors, coils, etc. with the soldering iron.
2. When removing wires from soldering lugs, be careful not to break the lugs with excessive pressure of your pliers.
3. Be careful that small lumps of melted solder do not flow down into tube socket contacts and clog them.
4. Make a note or a sketch showing where the disconnected wire or part belongs so that it can be reconnected properly.

After the resistor has been disconnected at one end, the ohmmeter should be placed across it and a resistance reading should be taken. (Fingers should be kept off the test prod tips; otherwise your body will act as a shunt across the ohmmeter and will make the resistance lower than its true value.) Let's say that the meter reads 220,000 ohms. This is too high a value. The resistor is faulty and should be replaced.

Resistor R_1 might have had one of the other four possible faults. For instance, it might have had too low a resistance, and you would have learned this by using the ohmmeter. It might have been an open resistor. Open resistors register at the calibration for infinity (∞) at the extreme end of the ohmmeter scale. However, the ohmmeter would not have been so reliable a test instrument for a noisy resistor. When an ohmmeter is placed across a noisy resistor, the indicating pointer sometimes, but not always, wavers or sways back and forth. Loose or dirty contacts can also result in a wavering pointer, even when the resistor being tested is not open; when testing any resistor, make certain that the ohmmeter leads are firmly connected to the ohmmeter pin jacks and the resistor being tested.

If the carbon resistor had an abnormal change in resistance value when it became hot due to current flow, there would have been no indication of this on the ohmmeter. When the resistor cools down after shutting off the radio receiver, its resistance value

will probably return to normal. You will learn how to find this trouble in a later lesson.

Replacing Resistors. A faulty resistor should be replaced with another resistor having the correct resistance, wattage, and tolerance. A resistor with a greater wattage rating may be used if space permits. A resistor with a closer tolerance value may be used if the original value is not obtainable. It is possible to replace a resistor made of one material with a resistor made of another material. If d-c or low frequency a-c current (60 cps) flows through the resistor, a carbon, metallic-film, or wirewound resistor can be used as a replacement. If r-f current (signal) flows through the resistor, only carbon, metallic-film, or special types of wirewound resistors should be used as replacements. However, until you have had considerable experience in repairing receivers, replace a faulty resistor with one made of the same material as the original.

It is almost impossible for a resistor to become short-circuited (shorted). Of course it is possible for the leads to touch each other, or for both leads to touch some common point. Except for these conditions, an ohmmeter placed across a resistor may show that the resistance is correct, too high, or too low, but should never show that it is zero.

Caution: When installing new resistors, remember the following:

1. Do not cut the new resistor wires too short; the heat of the soldering iron will travel along the short wires when solder is applied and change the resistance.

2. Do not allow blobs of melted solder to fall on other parts.

3. Place the new resistor in the same physical location that the defective resistor occupied. Dress the resistance leads by keeping them in the clear, and cut off excess wire at the solder joints.

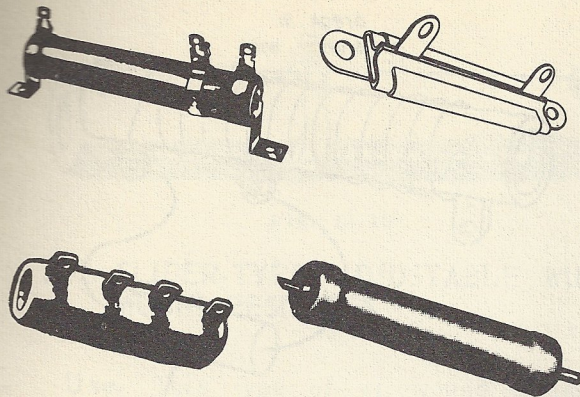


Fig. 13-5

Fixed Wirewound Resistors. When the current flow through certain portions of a radio receiver is too large to be handled by the ordinary carbon resistor, a wirewound resistor is used. This type of resistor can safely give off more heat than a carbon resistor or metal-film resistor of the same dimensions. The most common types of fixed wirewound resistors are those shown in Fig. 13-5.

Wirewound resistors do not have color-code markings. Their resistance values, in numbers, are printed directly on them. Sometimes the markings disappear, due to heating of the resistors. Sometimes there may be no value printed on a new resistor. If in doubt about the normal-resistance value of an open wirewound resistor, refer either to the radio receiver circuit diagram or to the service and repair data.

The most common faults found in wirewound resistors are an open resistor (or open section of a tapped resistor) and an intermittent resistor. Figure 13-6 shows some typical defects. When an ohmmeter is used to test a wirewound resistor, the procedure is the same as when testing for a carbon composition resistor. An open resistor is easy to test and should be replaced when located. On the other hand, an intermittent resistor may test *normal* when the ohmmeter is applied to it. At another time it may test *open* or seem to have a resistance that is much higher than normal. At still

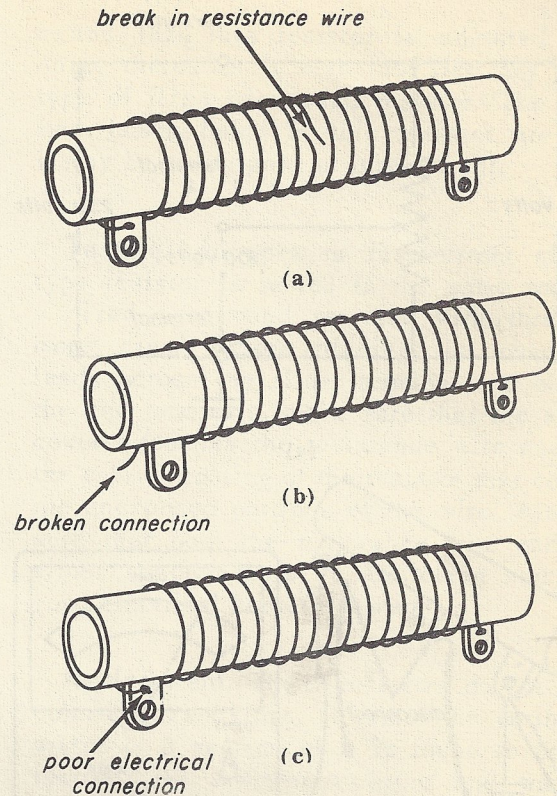
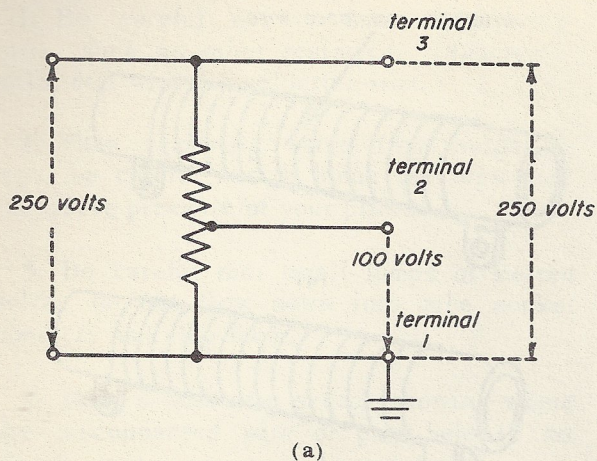


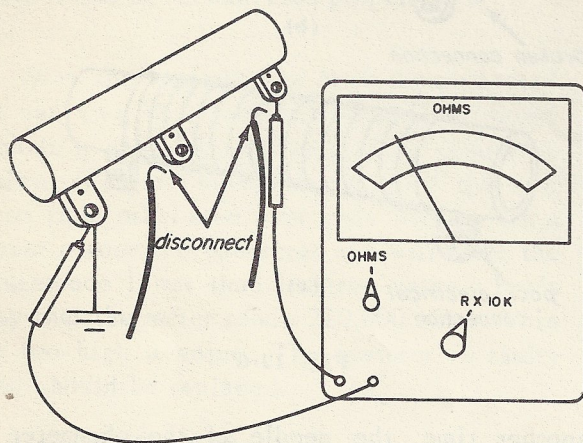
Fig. 13-6

another time, the needle of the ohmmeter may waver back and forth, indicating that the resistor is intermittent. Once you know that a resistor is intermittent, you should replace it.

When testing a tapped wirewound resistor with an ohmmeter, we must consider it as two resistors connected in series. Such a resistor, as shown in Fig. 13-7a, may be used in a voltage-divider circuit to provide different voltages. (The schematic shows that the voltage between the tap (terminal 2) and ground (terminal 1) is less than that between the top (terminal 3) and ground. The tap (terminal 2) is the common connection or joining-point of the two resistor sections. This means that before the ohmmeter leads are applied, at least two terminals or lugs should be disconnected, as in Fig. 13-7b, to avoid parallel-circuit effects and wrong readings. The ohmmeter leads then can be placed across terminals 1 and 2 and one resistance reading can be taken. Another reading can be taken with the ohmmeter connected to terminals 2 and 3.



(a)



(b)

Fig. 13-7

Each of the two sections may be open, intermittent, or perfect. The meter indications for each condition are the same as for untapped resistors.

If one section of a tapped resistor tests *defective*, it is best to replace the entire resistor. Of course, it is possible to replace the defective section by shunting it with a new resistor of the proper resistance value, as shown in Fig. 13-8. This shunt resistor does not necessarily have to be wirewound. If the power dissipated in the section does not exceed the capacity of a carbon composition resistor of the required resistance, there is no reason why such a resistor may not be used except in some very unusual cases. However, such a repair should be considered only temporary. The entire resistor should be replaced as soon as one is available.

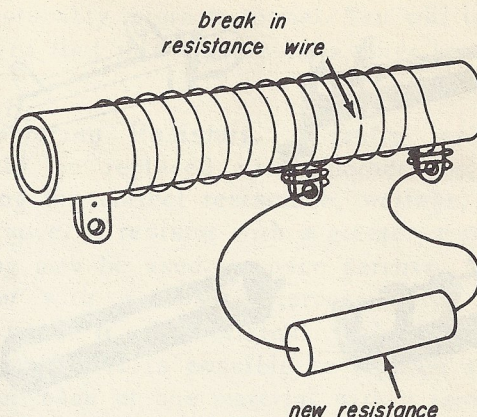


Fig. 13-8

Of course, you probably want to know why you should not shunt a section of a tapped wirewound resistor and consider it a permanent repair. Here's why: an open or intermittent section of a wirewound resistor may receive quite a bit of heat from the good section (or sections) of the resistor. This heat may cause the wire in the defective section to expand enough so that the open wire ends come together again and remain together just so long as the resistor is hot. When this happens, the resistance of the defective section will be in parallel with the shunt resistor, as shown in Fig. 13-9, and the resistance of the section will be about one-half what it should be. This will change the operating conditions of the equipment and cause it to operate improperly. It pays to play safe and change the entire resistor. When the resistor is replaced, each section between terminals or lugs should have the same resistance value and wattage rating as the original section.

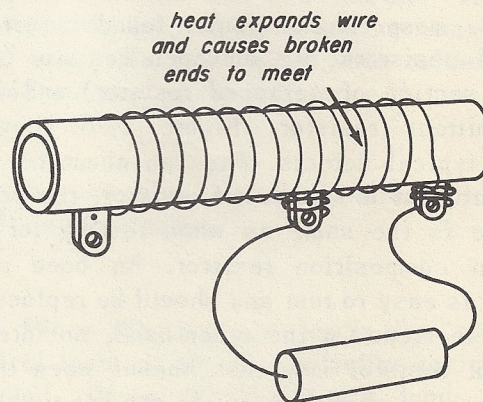


Fig. 13-9

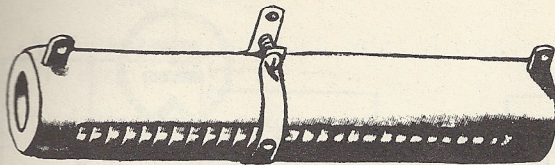


Fig. 13-10

13-2. SLIDER-TYPE ADJUSTABLE WIREWOUND RESISTORS

Use. This type of wirewound resistor, shown in Fig. 13-10, is neither a fixed nor a variable resistor, but half-way between these two types. It has one or more adjustable sliding contacts, in the form of a sliding sleeve that make contact with the exposed resistance wire of the resistor. This contact can be slid down the resistance wire until the desired amount of resistance is obtained. Then the sliding contact can be fixed in place by tightening a screw that causes the sleeve contact to grip the body of the resistor firmly and make firm contact with the resistance wire.

Caution: The slider pressure screw should not be tightened too much; excessive pressure of the slider contact against the resistance wire may cause the wire to break off at the point of contact or cause the ceramic form that it is wound on to crack.

Soldering lugs are provided for terminal connections. The sliding contact is usually left in its tightened position after the correct resistance point has been obtained. This

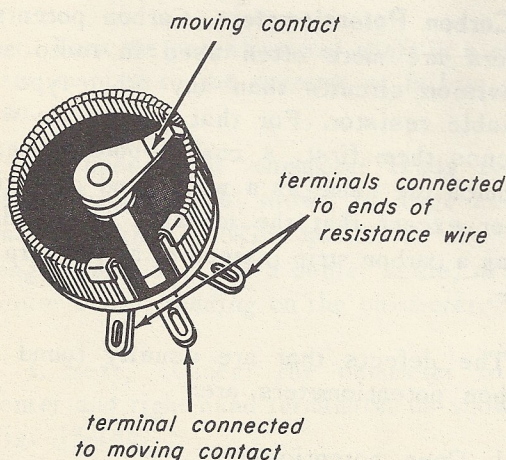


Fig. 13-11

means that this resistor is adjusted only once; thereafter it acts just like any other type of fixed wirewound resistor. The common faults found in this resistor are that it may be either open or intermittent.

Testing. An open or intermittent slider-type resistor is tested in the same way as a fixed wirewound resistor with three or more taps. Before placing the ohmmeter leads across the slider terminal and one of the end terminals, make sure that the slider contact touches the resistance wire and not the enamel coating of the resistor that covers the unexposed portions of the wire. Also be sure that both the resistance wire and the slider contact surfaces are clean and that good electrical contact is made.

Replacement. These resistors do not have color-code markings. If either the entire resistor or a section of it is found to be defective, the resistance value and wattage rating should be determined. After a little experience, you will be able to judge the wattage rating of most wirewound resistors. The complete resistor can be replaced, or the open section can be shunted with a section of another slider-type adjustable wirewound resistor. A fixed resistor cannot, as a rule, be used for a shunt because fixed resistors do not come in the odd resistance values that are common in sections of slider-type resistors. The new section should have the same resistance value as the open section and have the same, or greater, wattage rating.

13-3. VARIABLE RESISTORS

A variable resistor, as shown in Fig. 13-11, is one in which a movable arm or slider makes contact with any point between the end terminals of a carbon composition or wirewound resistor. Such a resistor may be used as a rheostat or as a potentiometer. When used as a rheostat, the sliding arm and only one of the end terminals are used. As shown in Fig. 13-12a, a rheostat is actually a variable resistor. When the movable arm is near the left terminal of the rheostat, there is very little resistance in the circuit (more current flows) and the light glows brightly; while the farther it moves toward the

would keep changing — making the sound jumpy. Dirty potentiometers do not necessarily have to be replaced. There are various cleaning fluids and compounds on the market that have been specially prepared to clean a potentiometer so that it will operate as smoothly and quietly as when it was new. Instructions for applying them come with each type.

A potentiometer having a changed or incorrect value of resistance is tested by connecting the ohmmeter as shown in Fig. 13-14a. An ohmmeter reading is taken and the value obtained is compared with the resistance stamped on the case of the pot or obtained from servicing notes. If the resistance of the pot has changed so far from its normal value so that it actually affects the operation or tone quality of the radio receiver, it should be replaced. If the pot operates smoothly, and the radio receiver operates normally, no harm is done if the pot is not replaced, even though its resistance may be somewhat off the 20% maximum tolerance usually allowed resistors in radio receivers.

An intermittent carbon potentiometer is one that, due to a poor electrical connection within the pot, causes the circuit between two of the three lugs to either open or change its resistance at different times. To test for an intermittent potentiometer, proceed as follows:

1. Test the pot for any of the four previously mentioned defects. If everything is normal, proceed with the next step.

2. Connect the ohmmeter as shown in Fig. 13-14a. Place a piece of insulating tape between the two jaws of a pair of long-nose pliers. Grip one terminal of the potentiometer with the insulated pliers and force the lug slightly from side-to-side, at the same time holding the case of the potentiometer with the other hand. Watch the ohmmeter to see if the reading suddenly goes to infinity. If it does, the lug is loosely connected within the potentiometer. Release the pliers and then grip the other end terminal with the pliers, repeating the same procedure.

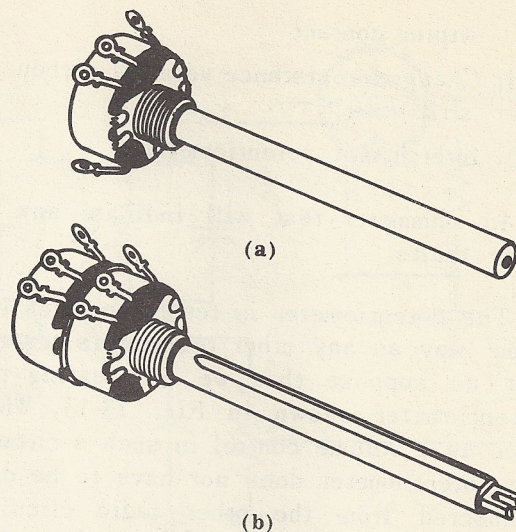


Fig. 13-15

3. Connect the ohmmeter leads to the center lug and the right-hand lug, as shown in Fig. 13-14b. Grip the center lug with the insulated pliers and check for a loose lug connection as before. If the potentiometer is intermittent, it should be replaced.

Some types of potentiometers have four terminal lugs, like the one shown in Fig. 13-15a. The same procedure is used for testing a pot of this type as is used for testing the three-lug type, except that the resistance between the fourth lug and the closest end lug is also determined by an ohmmeter check.

Another type of control, known as the *dual potentiometer* is shown in Fig. 13-5b. Each potentiometer of a dual potentiometer is tested separately.

13-4. TAPER

One test that must be made whenever a potentiometer becomes defective is that for *taper*. Taper is the term used to describe the way the resistance of the potentiometer's resistance strip varies from one end terminal to the other. We might expect that the resistance would increase evenly along the resistance strip. For example, we might expect that each quarter turn of the movable arm would cause it to slide across an equal amount of the resistance of the resistor strip, as in Fig. 13-16. Some potentiometers act just this way. When they do, we say that they have a *linear taper* — because the

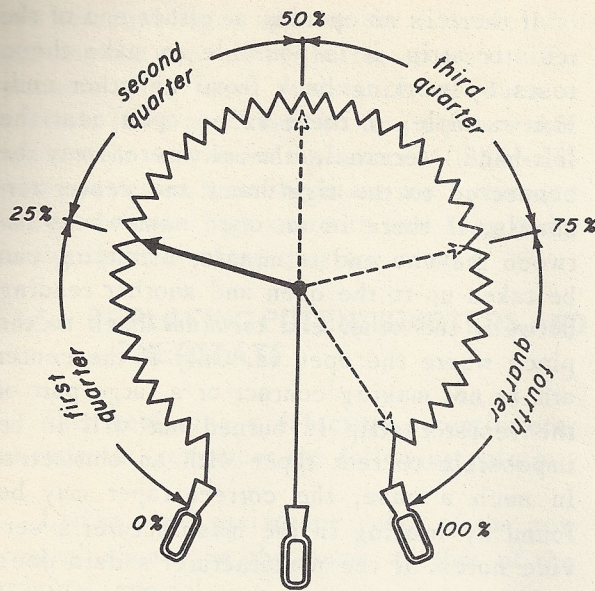


Fig. 13-16

resistance increases in a straight line, evenly. However, the greater number of the potentiometers used in volume, tone, and other control circuits in radio and television do not have a linear taper. Most tapers are determined by comparing the resistance of the second half-rotation. In some cases the resistance in one half-rotation of the movable arm may be much greater or much smaller than in the next half-rotation. Why this should be so is discussed in later theory lessons. At this time it is necessary only that you know how to identify the more common tapers used in potentiometers.

Unfortunately the manufacturers of potentiometers do not agree on any means of identifying the different tapers used in

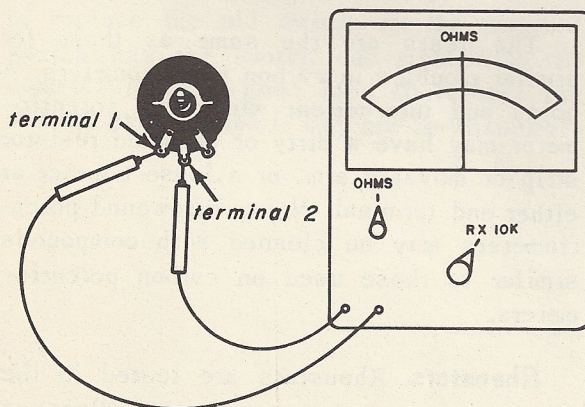


Fig. 13-17

potentiometers, so when you look in a parts catalog, you'll find that one manufacturer calls his linear taper #4, another identifies his as an A taper, and still another marks his C-1. Each one means the same thing but says it differently.

However, it is possible to measure the taper of most potentiometers with your ohmmeter so that you may know which taper to order from your parts dealer. Here's how you do it:

1. Hold the potentiometer with the lugs down and the shaft toward you, as in Fig. 13-17.

2. Connect the leads of your ohmmeter to terminals 1 and 2, as shown.

3. Turn the shaft counter clockwise (toward terminal 1) as far as it will go. Then advance it slowly in a clockwise direction and watch the resistance increase by watching the ohmmeter needle. If the resistance measured at the halfway point is half the total resistance, as in Fig. 13-18a, then the potentiometer probably has a linear taper. To make sure, repeat the test even more carefully. This time notice how the resistance increases as you start turning in a clockwise direction away from terminal 1. If the resistance change is very slow at first and then speeds up and changes at an even rate until just toward the end, where the change rate slows down again, you may have what is called a *symmetrical taper*. If the first half-rotation passes 1/10 of the total resistance, with the other 9/10 in the second half, you have a potentiometer with a *left-hand logarithmic taper*, as in Fig. 13-18b. If the first half passes 9/10 and the second half 1/10, then you have a *right-hand, logarithmic taper*, as in Fig. 13-18c. If the first half-rotation passes 2/10 and the second half 8/10 of the total resistance, as in Fig. 13-8d, it is a *left-hand, semi-logarithmic taper*. If the first half rotation passes 8/10 and the second half 2/10 of the total resistance, as shown in Fig. 13-8e, it is a *right-hand, semi-logarithmic taper*.

two terminal lugs, one for the movable arm and one for one end of the resistor strip. To measure the total resistance of such a control, it is necessary to turn the movable arm to the maximum resistance (full clockwise) position. Most rheostats are wirewound because of the high currents that they carry in the circuits where they are used.

13-5. REPLACING POTENTIOMETERS AND RHEOSTATS

When replacing a defective potentiometer or rheostat, remember the following points:

1. The total resistance value of the new control should be the same as that of the original control.
2. The wattage rating of the new control should be at least the same as the wattage rating of the original. Sometimes a higher wattage control may be used, if space permits.
3. A wirewound control must be replaced with a wirewound control, and a carbon control with a carbon control.
4. The new control must have the same taper as the one being replaced.
5. If the control has some special feature, such as a tap at some point between the two end terminals, the new control must be tapped at the same point.
6. If the control has a switch attached to it, as on an ON-OFF switch and volume control combination, it is usually necessary to replace the old switch as the original switch has the switch cap riveted to the control. It is a good idea to replace the switch, even though it may not be absolutely

necessary, because the switch and control are made to have about the same service life.

7. Make sure that the replacement control has a shaft similar to that which it replaces, so that the control knob may be properly attached. The new shaft may not be of the same length as the old one, so it may be necessary to remove (with a hacksaw) some of the new shaft to bring it down to the length of the old one. On the new shaft, measure off the length of the old shaft, as in Fig. 13-19. Then remove the excess with your hacksaw.

8. Before unsoldering the leads and removing the old potentiometer or rheostat from the chassis, make a drawing showing the connections to each terminal lug or mark each lead so that it may be connected to the correct terminal in the new control.

Once the potentiometer or rheostat is disconnected from the receiver circuits, it is easily removed by removing the mounting nut with an open-end or socket wrench of the correct size.

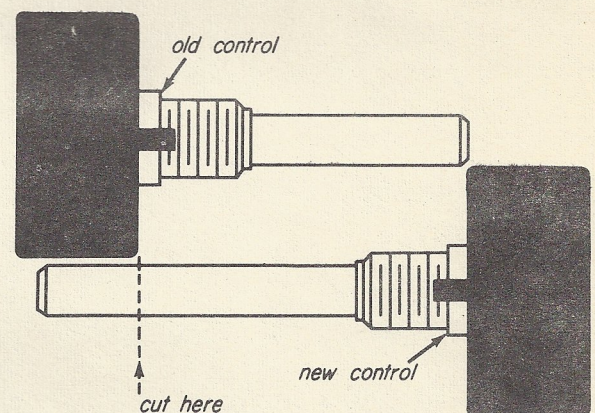


Fig. 13-19